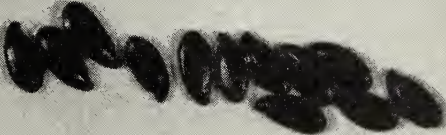
Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

FLAX

PRODUCTION



IN THE

IMPERIAL

VALLEY

KNOWLES · ISOM · WORKER

CIRCULAR 480

CALIFORNIA AGRICULTURAL
Experiment Station
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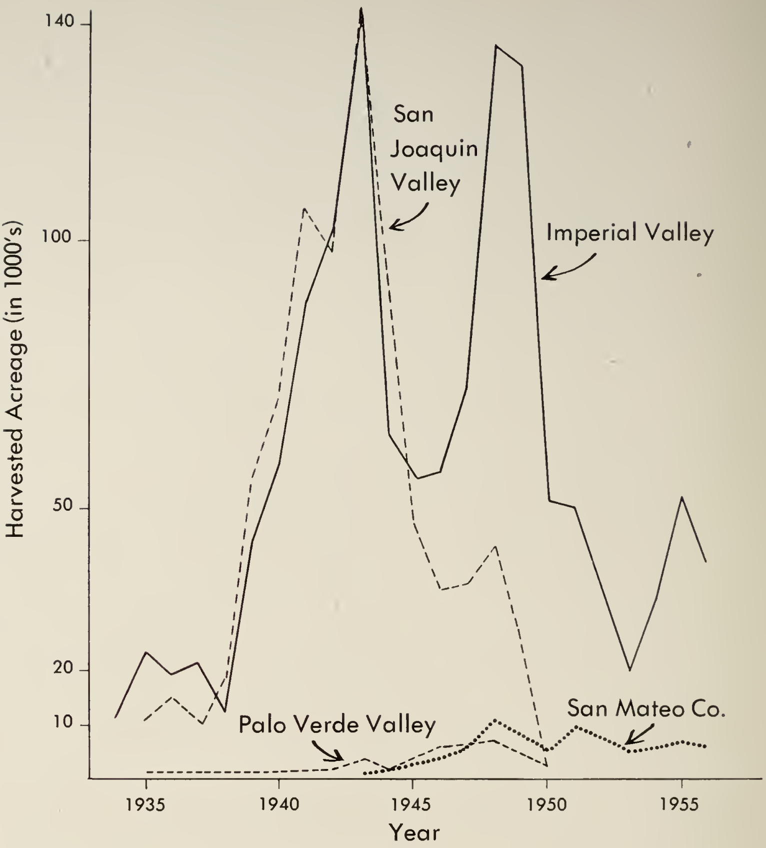

Flax Production in California

Flax, a newcomer among California crops, became firmly established as a commercial crop of the Imperial Valley in 1934. Not much later flax production started in the San Joaquin Valley where acreages increased until 1945, then dropped sharply. In the meantime flax was tried as a summer crop in San Mateo County where it has been successfully grown since 1944.

The Authors:

P. F. Knowles is Associate Professor of Agronomy and Associate Agronomist in the Experiment Station, Davis; W. H. Isom is Research Agronomist, Crops Research Division, Agricultural Research Service, USDA; G. F. Worker is Assistant Specialist in Agronomy and Superintendent of the Imperial Valley Field Station.

JULY, 1959

FLAX PRODUCTION IN IMPERIAL VALLEY

FLAX IS A COOL-WEATHER crop. This characteristic adapts it well to the mild winter climate of Imperial Valley. Adequate irrigation water from the Colorado River and commercial fertilizers make flax production possible in this desert region. The ideal winter climate, however, adapts the region to the production of other important crops which compete with flax for acreage. Among the winter crops are barley, sugar beets, lettuce, carrots, and other vegetables and small grains. Summer crops are cotton, melons, grain sorghums, and forage sorghums. Alfalfa occupies a rather large acreage both as a winter and summer hay and pasture crop. It is also used to better balance the crop rotation. Because of the competition of these several crops for land, the acreage of each crop is likely to reflect its current price.

Growth of the flax plant

Seeds of flax germinate very quickly in the presence of moisture. Under normal field conditions the seedlings appear above the ground in a week, though they may be delayed by cool weather and deep seedings. The seedlings are not vigorous nor highly competitive with weeds.

If sown in early December the seedlings grow steadily until they are 4 to 8 inches high by the end of January. By mid-March, when blossoming commences, the plants are 15 to 30 inches high. There is little increase in height afterwards. The plants usually produce two or more strong lateral branches from the base of the main stem though these may be absent, or their number may be reduced by thick stands or less-than-optimum growth conditions. Smaller branches are abundant in the upper part of the plant, and these branches bear the flowers.

Flax varieties grown in Imperial Valley have blue, funnel-shaped flowers. (In other varieties flower color may vary from white, through various shades of blue and pink, to dark lavender. Flowers may vary also in shape and size).

Flowering continues over a long period if the flax plant has sufficient nutrients and water. The maximum amount of bloom occurs about one week after flowering commences, but the plants continue to bloom for two or three additional weeks. Normally this first flush of bloom produces mature bolls about the first of May. At this time the variety Imperial produces a large second flush of bloom. These will mature in early to mid-June, when a third flush of bloom may occur. These flowering periods are usually referred to as the "first, second and third sets." Flowers open about an hour after sunrise, and the petals fall about noon. Each day produces new flowers.

The bolls of flax varieties in the Imperial Valley are closed tightly (indehiscent), and are difficult to thresh without rolls on the combine. Each boll can produce up to 10 seeds, but normally the number varies from 8 to 10. An exceptional boll may produce more than 10 seeds, but it has not been possible to develop a variety that will do this consistently.

Seeds of flax may vary in color from yellow to dark brown, and in size from those weighing 3 grams per 1,000 seed to those weighing 12 grams. The seeds of varieties grown in Imperial Valley are brown, and 1,000 of them weigh 6 to 6.5 grams. Flax seed is covered with a mucilaginous material that gives it a high gloss. It also causes the seeds to stick together when they are wet.

The culture of flax

Flax culture in the Imperial Valley may vary from farm to farm, therefore successful practices will sometimes differ from those described here. The records of farmers participating in production contests have been very helpful in drafting the recommendations presented in this circular.

Climate

Flax grows best where temperatures are cool during most of the growing season. For this reason it is grown in the Northern Great Plains and in coastal areas of San Mateo County as a summer crop, and in Texas and the desert areas of the Southwest as a winter crop. Imperial Valley provides an ideal climate for flax, particularly for the varieties grown there. The table below gives some of the statistics on the climate of Imperial Valley. The high summer temperatures of this area begin after flax has completed most of its development.

In parts of the Northern Great Plains the growing season for flax is not much

Weather Data from El Centro, California (September 1950 to August 1955)*

Month	Rainfall	Temperatures				Average no. days below freezing	Wind speed	
		Average maximum	Average minimum	Lowest	Highest		Average	Maximum
	inches						m.p.h.	m.p.h.
September	Trace	105.3	66.2	54	120	0	7.1	38
October	0.00	95.7	57.5	40	109	0	5.9	32
November	0.14	79.9	46.2	30	94	0.8	7.0	35
December	0.24	71.0	39.1	25	86	4.8	7.4	43
January	0.87	69.3	38.7	26	85	4.2	7.5	33
February	0.05	74.4	41.3	26	93	3.6	8.3	38
March	0.28	78.5	45.7	29	94	0.2	8.5	40
April	0.12	87.6	52.3	34	107	0	9.1	47
May	0.00	96.0	58.6	44	116	0	9.2	35
June	0.00	103.2	64.8	47	118	0	8.4	30
July	0.19	108.9	76.0	52	120	0	10.0	51
August	0.76	107.2	74.5	59	117	0	9.2	54

* From U. S. Weather Bureau records.

over 100 days. In Imperial Valley it may extend from November to July, a period of more than 200 days. The long growing season is one reason for the high yields.

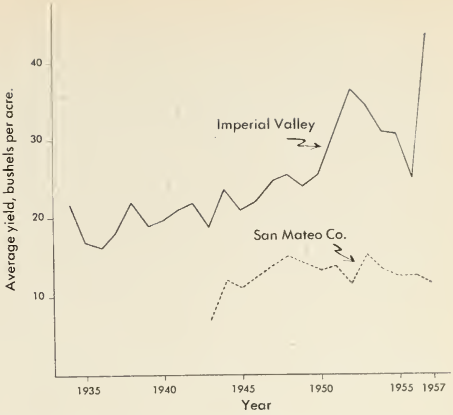
High or low humidities do not in themselves appear to be important factors in the culture of flax, since the crop thrives in the low humidities of Imperial Valley and the high humidities of San Mateo County. Diseases are often favored by high humidities, rust, Botrytis blight, and pasmo being severe at times in San Mateo County. Anthracnose appeared in the San Joaquin Valley when hot humid conditions prevailed in early spring.

Soil

Flax does best on medium-textured soil but is grown in Imperial Valley on soils that are sandy loams and clay loams. With the heavy soils it may be difficult to prepare a suitable seed bed.

Flax is more sensitive to salty soil than most field crops. It will not thrive nor produce a paying yield if the salt content of the soil extract is above 5 millimhos per centimeter. You may obtain this measurement in a laboratory prior to planting.

In the past it was often said that flax was "hard on the soil." Part of this impression stemmed from the fact that Fusarium wilt spread rapidly in new stands of flax in the Northern Great Plains, and prohibited the production of successive crops of flax. Weeds, commonly a problem in flax fields, may have affected yields of the succeeding crops. Flax does not produce a great volume of organic matter, and may not improve the texture of the soil, but there is no record in Imperial Valley that flax in itself has had an adverse effect on the soil.



Consistently high flax yields make the Imperial Valley the top flax-producing region of the state.

Crop Rotations Used in Flax Production, Imperial Valley*

Year in rotation					
1–3	4	5	6	7	8
Alfalfa	Flax	Flax			
Alfalfa	Flax	Flax	Flax/milo		
Alfalfa	Flax	Flax	Barley/milo		
Alfalfa	Flax	Flax/sesbania	Flax		
Alfalfa	Flax	Flax	Barley	Barley	
Alfalfa	Flax	Barley	Barley/milo		
Alfalfa	Flax	Flax/milo			
Alfalfa	Vegetables	Vegetables	Flax		
Alfalfa	Vegetables	Vegetables	Vegetables	Flax	Barley
Alfalfa	Flax	Flax/sesbania	Sugar beets	Vegetables	Vegetables
	Flax/sesbania	Flax	Flax/sesbania	Flax	Flax/sesbania

* From "An economic study of California Flaxseed Production," J. C. Deubner, 1947.

Rotation

Flax is included in many different rotations (see listings page 5), but over half the time it follows alfalfa. It is recommended after beets or a vegetable crop that has been kept free of weeds. After barley or wheat it is important to germinate and destroy seeds and seedlings of these crops, otherwise volunteer plants may become serious weeds in the flax.

Two or more flax crops may be grown in succession, though weeds may prohibit this practice. Frequently the second crop of flax after alfalfa is higher in yield than the first, presumably because the alfalfa has completely decomposed by the time the second flax crop is planted. On decomposition of the alfalfa residue, nitrogen becomes available to the flax plants. If grown continuously, diseases sometimes increase in flax, most conspicuously Fusarium wilt. After alfalfa, cutworms may be a problem.

The value of sesbania as a cover crop in a rotation with flax has not been proved. Limited experiments would indicate that flax yields are not increased following sesbania.

Varieties

Punjab (C.I. 20), a selection from an introduction from India, was the first successful variety in Imperial Valley. This variety has been almost completely replaced by the varieties Punjab 47 (C.I. 1115) and Imperial (C.I. 1114), both selections from Punjab, made by L. G. Goar, and both released for commercial production in 1947.

Punjab 47 is slightly higher yielding and somewhat earlier than Punjab, but otherwise very similar to it. Punjab 47 was widely grown in Imperial Valley

How Flax Varieties Compare in Yield, Oil Content, and Iodine Value

	Punjab (C.I. 20)	Punjab 47 (C.I. 1115)	Imperial (C.I. 1114)	Punjab 53	New River
U.C. Imperial Valley Field Station, El Centro:					
Yield bu./A 1945–52	41.2	44.3	44.0		
Yield bu./A 1952–56		50.4	50.4	45.0	
Yield bu./A 1956–57		41.0	47.6	45.9	44.5
Oil content in per cent 1945–52	39.8	41.0*	39.8*		
Oil content in per cent 1952–56		39.8	38.6	40.0	
Oil content in per cent 1956–57		39.4	39.2	40.2	42.0
Iodine value 1945–52	184	184*	184*		
Iodine value 1952–56		182	182	189	
Iodine value 1956–57		175	180	184	177
USDA Southwestern Irrigation Field Station, Brawley:					
Yield, bu.A. 1950–52	39.3	39.3	39.2		
Yield bu./A 1953–57		45.9	50.0	44.7	48.3
Oil content in per cent 1950–52	38.4	39.9	38.4		
Oil content in per cent 1953–57		40.1	38.8	39.8	42.1
Iodine value 1950–52	182	178	180		
Iodine value 1953–57		183	183	189	184

* No data for 1949.

following its release as a new variety. It has no resistance to wilt.

Imperial is somewhat later than Punjab, has slightly smaller seeds, and produces a more abundant "second set" of bolls in the late spring than either Punjab or Punjab 47. Where farmers have irrigated late to get a second set, Imperial has been the highest yielding variety. For this reason it has become increasingly popular in the Imperial Valley. The adoption of this variety with late dates of harvest has required some changes in the culture of flax. It has also led to very high yields. Imperial is not resistant to wilt.

Punjab 53 was developed by personnel of the University of California from a wilt-resistant selection of Punjab found in San Mateo County. In the absence of Fusarium wilt, it is not so high yielding as the above three varieties, but where this disease is present Punjab 53 is much superior. Though it has a high degree of resistance to many races of wilt, it is being replaced by New River.

New River (C.I. 1912), a variety developed by the U. S. Department of Agriculture, was derived from a cross between Punjab 47 and B-5128 (C.I. 980). It is resistant to most wilt races, and yields about the same as Imperial even where wilt is not a problem. It has a higher oil content than the varieties above.

All these varieties are very similar in appearance—they have short and branched stems, blue flowers, indehiscent bolls, and brown seed. The results of yield tests in Imperial Valley are given in the table on page 6.

Varieties from the Great Plains area have been distinctly lower in yield. Some with resistance to disease have been crossed with local varieties and may yield strains superior to anything now available.

Attempts to develop a flax variety with both high seed and high fiber yield have not been successful. The long-stemmed fiber types have given a low yield of very small seed.

Foundation, registered, and certified seed

The purity of the flax varieties Punjab 47, Punjab 53, Imperial and New River is maintained through foundation, registered, and certified seed.

Foundation seed is highly purified seed, grown in small amounts by the University, and distributed to a small number of growers. It is used to produce registered seed, the increase from the latter being called certified seed.

Certified seed, in most instances, is used to grow commercial seed for crushing, and only in special circumstances can it be used to produce certified seed for another generation. The Farm Advisors' office in Imperial County has a list of farmers having registered or certified seed of the different varieties. The list is revised each year.

In most instances it pays to use certified seed. It assures your getting the correct variety, free from mixtures and of a high germination rate.

Seedbed preparation

The seedbed should be firm, level, and have moist soil as close to the surface as possible. Germinate weed seeds and destroy the seedlings before planting.

When flax is to follow alfalfa or other perennial crops, plow the land in the summer or very early fall. You may turn under the last crop of alfalfa, to increase the organic matter in the soil. After barley, wheat or other winter crops chisel the land in the early summer and leave to aerate until September when it is disked prior to the first pre-irrigation—that is, an irrigation given prior to planting. A summer cover crop before the flax

Foundation seed of Punjab 47 at the Imperial Valley Field Station, grown under isolation and all off-types rogued out.

should be plowed under in August while it is still green. After a row crop such as melons, lettuce, or carrots, deep tillage probably is not necessary, and disking will suffice.

About September 1 or shortly thereafter prepare the land for a pre-irrigation. After disking, make the irrigation levees or "borders," parallel to one another and 40 to 60 feet apart. The enclosed areas, the "checks," may vary in length from 300 feet to ½ mile. The length and width of the checks depend upon the volume of water delivered at the head of the check and the type of soil. On sandy soil make the checks narrower and shorter because they lead to more economical use of water. Leave the borders as low as possible—the settled height should be about 6 inches. This permits easier planting and harvesting.

Pre-irrigation for flax in November aims at water penetration to a depth of 3 to 4 feet.

If you use a single pre-irrigation, allow 10 to 25 days before seeding: a short period for light or sandy soils and a longer period for heavy soils.

Apply enough water to wet the ground to a depth of 3 to 4 feet. Soil should be saturated through the effective root zone, and water should move into the tile lines. When the soil has dried sufficiently, give it a shallow cultivation (mulching), thorough enough to kill all weeds. Avoid deep cultivation because it will bring weed seeds up from lower levels, and these will germinate and grow with the flax. A spring-toothed harrow or a mulching disk followed by a spike-toothed harrow is usually sufficient. A packer or roller may be used in some cases to firm the soil. If the soil is weedy, it may be advisable to let a second crop of weed seeds germinate, and then cultivate a second time (double mulching).

Two pre-irrigations have been used by many farmers to good advantage. The timing of these pre-irrigations will depend upon the date of planting, but the first may be given as early as mid-September. The first irrigation will germinate some seeds of both summer and winter weeds, and also indicate the high and low spots in the field which may be eliminated by landplanning before the second pre-irrigation. Destroy the weeds about six weeks later, in the manner described above. After the last cultivation, sow the flax immediately.

Preplanting fertilization

Fertilizer recommendations vary from farm to farm, and are influenced on the same farm by the various soil types and the previous history of cropping and fertilizing.

Phosphorus (P) has been used rather liberally in Imperial Valley, and many fields show no response to its use. If used, 40 to 80 pounds per acre of P_2O_5 should be adequate. Apply it just ahead of the last pre-irrigation, either as broadcast on the surface of the soil or drilled in to a depth of 4 to 5 inches.

Apply part or all the nitrogen (N) fertilizer at the same time as the phosphorus. You may use a combination-type fertilizer such as 13-39-0, 16-20-0, or 11-48-0 (nitrogen, phosphorus, and potassium, respectively). At this time, apply 40 to 100 pounds of nitrogen. On sandy soils use the ammonia form or urea rather than the nitrate form, since the latter may be readily leached from the surface layers by irrigation water. The form appears to be less important with the heavy clay soils.

There is no evidence that flax in Imperial Valley benefits from potassium (K) fertilizers. Neither have flax yields been improved by the use of micronutrients.

Fertilizers are sometimes applied before the cultivations prior to the last pre-irrigation. However, if temperatures are high at this time, much of the ammoniacal nitrogen may quickly change to the nitrate form, be leached from the surface layers of soil, and perhaps lost to the flax crop.

Planting

Equipment: Usually a grain drill is used for planting. It should be set to place the seed into moist soil about ½ to 1 inch, but at the same time as shallow

Top: Cultivation with a spring tooth harrow after the first irrigation, destroying a heavy stand of small weeds. Center: Mulching with spring tooth and spike tooth harrows. Bottom: Double-disk planter with press wheels and cultipacker. The press wheels run in the bottom of the furrows behind the planters, and firm the soil about the seed.

as possible. In desert areas, where rain rarely occurs at the time of seeding, good stands are obtained by planting to a total depth of 2 or even 3 inches, if the surface soil is dry and fine, and the seed is placed in firm moist soil. A drill with a shoe-type or double disk opener and individual press wheels is most suitable since it places the seed into moist soil without covering the seed too much. Packing after seeding may be desirable if the drill does not have press wheels. Avoid planting in soil that is so wet that it will not close around the seed. The seed will not germinate if it sits in the bottom of an open furrow.

Broadcasting and harrowing is not recommended, because these practices place many of the seeds too deep, or too shallow, to produce seedlings. Also, broadcasting usually requires an irrigation to germinate the seed; and an irrigation after broadcasting, or after drilling the seed near the surface in dry soil, germinates many weed seeds and may crust the soil.

The common practice is to drill lengthwise of the checks. Drilling crosswise is more difficult, and often leads to uneven stands on each side of the borders because the seed is sown too deep or too shallow. However, some of the advantages of drilling crosswise are:

- the borders grow flax instead of weeds,
- the drill furrows lead to more uniform distribution of water, and
- the furrows on each side of the border are partially filled which makes harvesting easier.

Rate: The rate of seeding in close-drill rows (6 to 8 inches apart) should be about 42 pounds per acre. It may be increased to 50 to 60 pounds per acre if curly top is expected. Excessively heavy stands, however, frequently lodge because the plants are crowded and stems thin and elongated.

At 42 pounds per acre, you sow between 60 and 70 seeds per square foot. If ⅔ to ¾ of these develop into seedlings, the stand is adequate. If plants are about ½ inch apart in rows 6 to 8 inches apart, the stand is satisfactory.

Seed treatment: Treat the seed with a fungicide to kill any disease that may be present on the surface of the seed. Currently recommended fungicides are Ceresan M and Arasan SFX. A recommended fungicide will also protect the germinating seed from root rots, this being particularly important where germination proceeds slowly because the soil is cold and wet. The protection that a fungicide affords the young seedling does not extend beyond its emergence above the surface of the soil. Use fungicides at the rate recommended by the manufacturer, and apply them as either a dust or slurry. Most seed flax supplied by Imperial Valley firms and organizations is treated prior to sale to farmers.

Date: When Punjab and Punjab 47 were the varieties commonly grown, the period from November 7 to December 7 was most suitable for planting. These varieties were harvested in May and June. With Imperial, which is harvested in July, plantings made during the first two weeks of December have been higher yielding in many cases than those made earlier or later. If sown in October, buds and flowers may appear early enough in February or March to be damaged by frosts. Appreciable amounts of flax have been successfully and profitably sown in late January and early February after an early crop of lettuce or carrots. Plant height will decrease with later plantings.

Row culture: Though not a frequent practice, flax has been grown successfully in Imperial Valley as a cultivated wide-row crop. At spacings of 24 inches or less between rows, yields have been similar to those where drill rows were 6 to 8 inches apart. In wide-row plantings it is preferable if the rows run in a north-south direction to promote a set of bolls on both sides of the row. Rows running east to west produce more bolls on the south side, and may lodge in that direction. Rates of seeding: for 18-inch rows 32 pounds per acre; for 21-inch rows 28 pounds; and for 24-inch rows 24 pounds.

Irrigation

Irrigate 6 to 8 weeks after planting when the plants are 4 to 8 inches high, and before they develop a deep green or bluish color which indicates stress from lack of water. However, an irrigation trial in a commercial field in 1955–56 (see table below) indicated that the initial irrigation after planting should be delayed as long as possible without allowing the plants to wilt. Early irrigations encourage weeds, root rots and lodging.

Give the second irrigation about one month after the first, when the plants are in full bloom. Delaying the second irrigation much beyond 30 days has caused a reduction in yield. Frequent irrigations before full bloom may promote lodging which results in lower yields.

Provide succeeding irrigations often enough to prevent stress from drought. Soil type, weather conditions, and stage of growth will regulate the applications. It is a bad practice to irrigate by the calendar.

For a second set of bolls and maximum yields, continue irrigations into June; keep irrigating so long as the flax stands upright, remains green, and continues to bloom. Ten or more irrigations may be necessary.

Since flax bolls mature successively over a long period, it is difficult to state in terms of their development when irrigations should cease. Normally they will stop about three weeks before harvest. The total water used on flax amounts to 3 to 4 acre feet.

Frost damage

Damage to flax from frost occurs almost every year in the Imperial Valley. Most often it occurs in early March, when temperatures of 28° to 30° F kill blossoms and young bolls—the rest of the plant is unaffected. Very often damage is not apparent until the affected bolls fail to develop and turn brown. Undoubtedly frost causes some loss in yield, though it has never been precisely measured.

When seedlings first appear above ground they are somewhat susceptible to frost. Temperatures below 18° to 26° F may kill them. After true leaves have formed and before flower buds appear, flax, in certain cases, has survived temperatures down to 15° F. At this stage, though frost may kill almost all the aerial parts of the plant, the main stem develops new branches at its base.

Damage from frost is affected by many factors. A period of cool weather prior to the frost will harden the plant, and thereby reduce damage. Bright sunlight and drying winds after a freeze may magnify its effect. Frost will do less damage if the level of soil moisture is high. For this reason many farmers irrigate their flax if frost is expected.

Effect of Irrigation Schedule on Yields

	Irrigations (√) at the following number of days after planting									Yield
	49	58	89	108	121	128	141	156	161	bu/A
Trial 1..........		√	√	√	√		√	√	√	44.3
Trial 2..........	√		√	√	√		√	√	√	39.6
Trial 3..........		√		√		√	√	√	√	38.1
Trial 4..........	√				√		√	√	√	34.2

In all four trials flax was planted November 15 at 50 lb/A. 150 lb. N and 80 lb P_2O_5/A applied before planting, 50 lb P_2O_5 at second irrigation, and 40 lb N in March. Soil type was Meloland fine sandy loam.

Postemergence fertilization

In recent years, as the culture of flax has been extended into June and July, more and more nitrogen fertilizer has been applied to the growing crop. The total amount of applied nitrogen, including preplant application, has often been as high as 200 pounds per acre. If nitrogen is not lost through leaching, 150 pounds per acre should be sufficient for maximum yields, even when following nitrogen-depleting crops such as sudangrass, sorghums and cotton.

Normally, large amounts of nitrogen should not be required when the flax is in the seedling stage. Some may be necessary if the plants are unthrifty or yellowish green. At this stage nitrogen is applied most efficiently by broadcasting ammonium sulfate or nitrate from a ground rig and irrigating immediately. Broadcasting is best done when the plants are dry, to avoid burning of foliage.

Postemergence fertilization is most effective when the plants are in bloom. There is some evidence that the second set of bolls is increased by nitrogen fertilizer which was applied when the second set of blooms appeared.

Postemergence nitrogen is often applied in the irrigation water in the form of anhydrous ammonia, aqua ammonia, or an ammonium nitrate solution. This usually leads to inefficient use of the nitrogen, since more irrigation water (and too much nitrogen) is taken into the front and back ends of the checks than in the middle. Some ammonia volatilizes during the application, and the loss will be higher as the temperature, akalinity and aeration of the water increases. Up to 25 per cent of the nitrogen may be lost in this manner. When you do apply nitrogen in irrigation water to seedling plants, keep the amount below 60 pounds per acre. Amounts above 90 pounds per acre have caused some damage to plants by defoliation, but the degree of damage has not been determined experimentally.

Airplane applications of nitrogen fertilizer to plants past the seedling stage deserve serious consideration. While such applications are costly ($1.50 to $2.00 per acre for the application alone) they do permit even distribution, and there is practically no loss through volatilization. Apply at a time when there is no dew on the plants, and follow up immediately with an irrigation.

Weed control and other uses of herbicides

Flax, a small plant and not strongly competitive, is easily overcome by weeds, particularly if both emerge at the same time. Weeds not only greatly reduce the yield of the flax, but may also decrease the oil content and iodine value of the oil (see table on page 13). Green weed seeds in the harvested flax seed may cause heating and damage.

The most serious winter weeds affecting flax in the Imperial Valley are wild oats, canary grass, wild mustard, Indian mustard, lambsquarters, nettle-leafed goosefoot, wild beets, sour clover and redweed. Troublesome summer weeds are wild sunflower, pigweed and water grass. (The scientific names of these weeds appear on page 27.) Volunteer barley, wheat, oats, grain sorghum and sudangrass may also behave as weeds in flax fields.

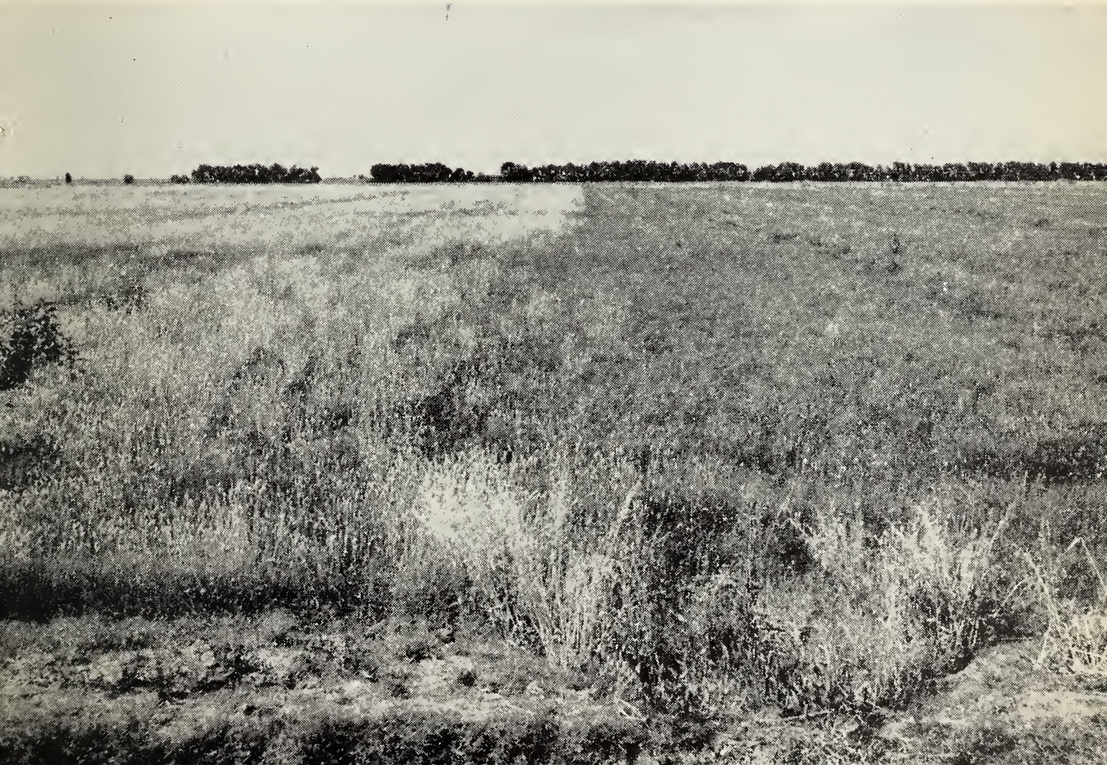
Much of the information on weed control with herbicides has been developed during the past few years. With new herbicides appearing each year the recommendations made here will change. See your local University of California Farm Advisor for new developments. Also remember: permanent control of weeds is dependent upon good cultural and rotational practices; herbicides are not substitutes.

Weeds Reduce Yield, Oil Content, Iodine Value
(Test of herbicides on flax at the Imperial Valley Field Station)

Herbicide	Rate of application	Yield	Oil analyses	
	lb/A	bu/A	per cent	iodine value
On Punjab 47, moderately heavy stand of broad-leaved weeds, 1951–1952:				
No herbicide, weeds removed	..	56.0	....	....
No herbicide, weeds not removed	..	32.3	....	....
2,4-D, triethanolamine salt	¾	55.5	....	....
MCP, diethanolamine salt	¾	45.5*	....	....
2,4-D, triethanolamine salt and IPC†	¾	52.4	....	....
MCP, diethanolamine salt and IPC†	¾	44.5*	....	....
On Punjab 47, heavy stand of canary grass, 1951–1952:				
No herbicide, weeds removed	..	53.7	36.7	182
No herbicide, weeds not removed	..	16.1	34.4	168
IPC, 50 per cent wettable powder	3	53.0	37.8	181
IPC, 50 per cent wettable powder	4	49.3	38.2	179
IPC, emulsified	3	53.2	36.9	180
IPC, emulsified	4	52.8	37.9	179
IPC, chlorinated	2	31.7	37.8	178
IPC, chlorinated	3	31.5	37.6	177

* Sour clover not killed.
† 50 per cent wettable IPC at 3 lb. actual IPC per acre.

Weed-control experiment: the left side of the field is heavily infested with wild oats and canary grass; the right side is controlled with 4 pounds of IPC per acre.



Left: Wild sunflower, a serious summer weed in flax. Right: Canary grass, an important winter weed.

Herbicides for broad-leaved weeds

Compounds of 2,4-D (2,4-dichlorophenoxyacetic acid): 2,4-D is a hormone-type herbicide which interferes with some of the vital processes of susceptible plants, causing severe plant distortion or death within one to three weeks. Flax, however, is tolerant of 2,4-D if the material is properly used. Flax may show some twisting of stems shortly after the application of the 2,4-D, but this is usually offset by new growth later on. Applications cost $2.50 to $3.00 per acre. Field experience and research (see table on page 13) indicate that 2,4-D will control broad-leaved weeds such as mustard and lambsquarters, and that it should be used in the following manner:

Use the amine salt of 2,4-D. It is sold as a liquid and goes readily into solution in water. The sodium and ammonium salts are about as effective as the amine, but more difficult to handle because they are solids. Ester compounds are more toxic to flax, and their volatile nature restricts their use in Imperial Valley.

Use $\frac{3}{4}$ pound of actual 2,4-D per acre. This is $1\frac{1}{2}$ pints if the formulation contains 4 pounds per gallon. Apply with a ground sprayer with 35 to 50 gallons of water per acre. Pressure in the sprayer should be 20–40 pounds per square inch and the nozzle size No. 8008. Increase the pressure as the forward speed of the rig is increased.

Apply as soon as possible after the first irrigation when seedlings of broad-leaved weeds have two or three leaves. Apply earlier if vigorously growing weed seedlings appear before the first irrigation. For best results, apply when the flax seedlings are 3 to 4 inches high, and preferably not over 8 inches, and when the weed seedlings are not higher than 5 inches and growing vigorously. Late-season applications are not advisable as 2,4-D is very toxic to buds, flowers and young bolls. Spraying when temperatures are high (over 85° F.) in the early fall or the late spring is more conducive to flax injury than when temperatures are cool.

Do not use 2,4-D on fields of flax heavily infected with curly top. Apparently the plants are in a weakened condition, and more sensitive to damage from 2,4-D.

Compounds of MCP (2-methyl-4-chlorophenoxyacetic acid): MCP is very similar to 2,4-D in its effect on most plants. It is more expensive than 2,4-D, with applications costing $4.00 to $5.00 per acre. Rather limited data from California would indicate that MCP is less toxic to flax, and less toxic to some weeds. In one test (table, page 13), it was less effective than 2,4-D in controlling sour clover. Rate, timing, and other procedures of applying MCP are the same as for 2,4-D.

Herbicides for grasses

IPC (Isopropyl-N-phenyl carbamate): IPC has been successfully used in the control of wild oats and canary grass. It inhibits cell division, but slows down or stops the growth of grasses only if it is washed into contact with the roots by irrigation water or rain. For this reason grasses on the borders of checks will not be controlled if they remain dry during an irrigation. IPC has no herbicidal effect on above-ground portions of the grass plant even if applied to them as a spray. Flax treated with IPC may be reduced in height. The cost lies between $10.00 and $12.00 per acre. Experience and research (table, page 13) indicates that IPC be used in the following manner:

Use the 50 per cent wettable powder or emulsion. The pelleted forms (tested in limited experiments) were not uniform in their effect—some flax plants were injured and some grass plants were unaffected, probably because of uneven distribution of the pellets. Do not use the chlorinated forms of IPC as they are very toxic to flax.

Apply at 3 to 4 pounds of actual IPC in 35 to 50 gallons of water per acre with a ground sprayer using pressures of 40 to 60 pounds per square inch. Include adequate agitation in the spray tank to insure even distribution of the material.

Apply before an irrigation when the flax is 2 inches and grass seedlings less than 5 inches high.

Harvest-time spraying for weed control

Where flax fields at harvest time are infested with large broad-leaved weeds, preharvest spraying may eliminate the necessity of windrowing. This treatment dries up both the green weeds and the late flax. It also permits earlier harvesting and may reduce the amounts of dockage with the seed. Spraying does not dry up the weeds where the weed stands are so heavy that their tops form a canopy and prevent penetration of the dessicating spray. The lower portions remain unsprayed and green, and direct combining of this material is impossible. Windrowing after a preharvest spray may then result in some loss of flax because the spray has made the plants brittle and susceptible to shattering. Spraying costs between $6.00 and $10.00 per acre. Use it in the following manner:

For each acre use 1 to 3 pints of dinitro general weed killer mixed with 8 to 15 gallons of diesel oil or weed oil. Use the smaller amount where moderate amounts of weeds are present, the larger where weed stands are heavy. Apply by airplane.

Apply when the flax is ripe. Harvesting should be completed within a week after treatment, or the weeds may become green again and require another treatment to permit direct combining. Some shattering of the flax may occur under this preharvest treatment but this shattering is usually less than that from windrowing.

Herbicides not recommended

Dinitro selectives: They are not as consistently effective as 2,4-D in controlling broad-leaved weeds and sometimes cause injury to the flax. Until replaced by 2,4-D the most widely used was dinitro-orthocresylate applied with ammonium sulfate. The ammonium salt of dinitro-ortho-secondary-butyl-phenol was also used without ammonium sulfate.

Oil sprays (mixture of kerosene and aromatic hydrocarbons): The high cost of $16.00 to $20.00 per acre prohibits their use on flax.

TCA (Trichloroacetic acid): This compound, though used effectively in the control of some annual grasses in the Northern Great Plains, does not control wild oats or the broad-leaved weeds of flax in the Imperial Valley.

Dalapon (Sodium salt of 2,2-dichloropropionic acid): Dalapon delays blossoming, maturity, and causes boll sterility in flax. When rates of 3, 4, and 6 pounds per acre were used on the variety Imperial, yields were reduced from 67 to 52, 42, and 34 bushels per acre respectively.

Maleic hydrazide: This herbicide has been toxic to both flax and wild oats.

Herbicides to delay blooming and escape frost damage

This practice is of doubtful value because it is difficult to predict the effect of the spray in this regard. It also requires the ability to predict the occurrence of frost a few weeks in advance.

Herbicides to shorten and stiffen the straw

Herbicides can be used to shorten the stems of flax, but this may be accompanied with a loss in yield. The plants often stand better simply because they have a smaller boll load to support.

Herbicides to cause branching

If the growing point of the stem is killed by a herbicide the stem will develop numerous branches immediately below the dead portion. Often these are spindly and weak, and there are no data to indicate that yield is increased by the herbicide.

Combined applications

A combination of 2,4-D and IPC has not been too successful. This may be due to the stress they place upon the flax, or it may be that they should be used at different times. IPC is best applied immediately before an irrigation, and 2,4-D immediately after.

Disease control

Only a few flax diseases are troublesome in Imperial Valley, including Fusarium wilt, Rhizoctonia, and curly top.

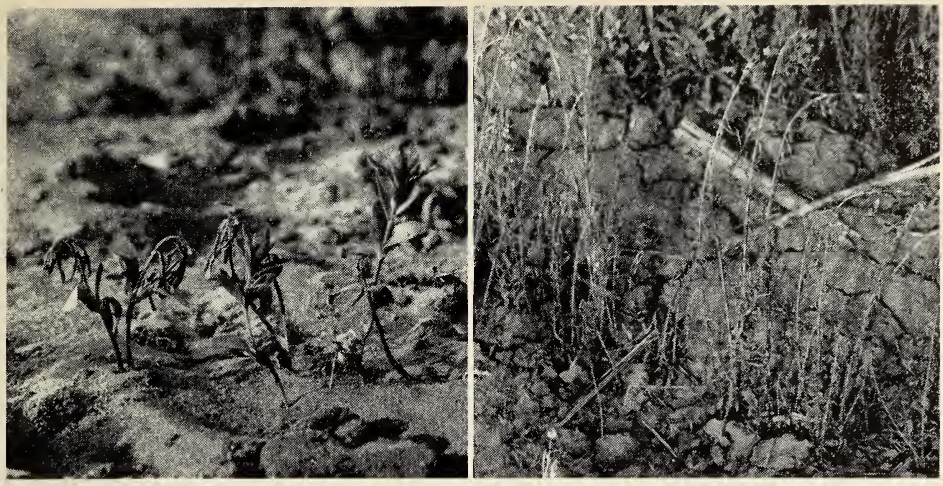
Disease-free seed: The original lot of Punjab seed used commercially in the Imperial Valley probably was free of diseases peculiar to flax. This would explain why flax in the Imperial Valley was not troubled by such diseases for so many years. The use of disease-free seed is particularly important if flax is moved from one county to another.

Seed treatment: Seed treatment kills spores of diseases present on the surface of the seed, but unfortunately does not penetrate inside. Seed treatment will also protect the germinating seedling for a few days, but only in the area of the seed. It will not control diseases such as Fusarium wilt that may be carried inside small sections of flax stems mixed with the flax seed.

Rotation: In the Imperial Valley rotations have not been effective in controlling Fusarium wilt and Rhizoctonia, the two most serious soil inhabiting pathogens of flax in that area. Rhizoctonia, of course, attacks many other crop plants.

Disease-resistant varieties: The flaxseed industry at the beginning of the century was threatened with destruction by Fusarium wilt, but was saved by wilt-resistant varieties. In the past 25 years resistant varieties have eliminated flax rust as an important disease in the Northern Great Plains.

The frustrating feature to the plant breeder is that the organisms causing disease—like crop plants—have many dif-



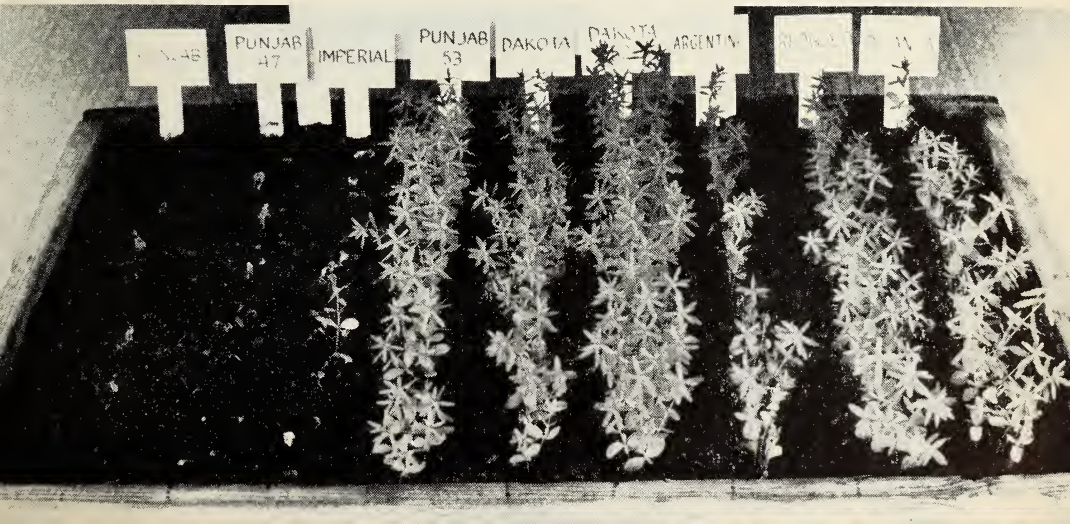
Left: Fusarium wilt attacking flax seedling. Note how the tip of the plant bends over sharply. Right: Flax plants killed by Fusarium wilt. This disease will kill susceptible varieties at any stage in development.

ferent varieties—usually called strains or races. A variety of flax may be resistant to one race and susceptible to another. That is the situation with both Punjab 53 and New River; they are resistant to many races of Fusarium wilt, but not to them all.

Fusarium wilt was first found in Imperial Valley in 1945, some eleven years after flax was grown commercially in that area. Since then it has become widespread in the Valley, and some fields are infested to a point where susceptible flax varieties can no longer be grown.

Fusarium is a soil inhabiting fungus that can attack flax at any stage. Because it prefers temperatures of 70 to 90° F. for best development, it frequently does not seriously damage flax in Imperial Valley until March. It can live on dead organic matter in the soil an indefinite period of time. This makes it difficult to control with crop rotation. It will not attack other crop plants.

Sample of the vast number of flax varieties tested for their resistance to many races of Fusarium wilt.



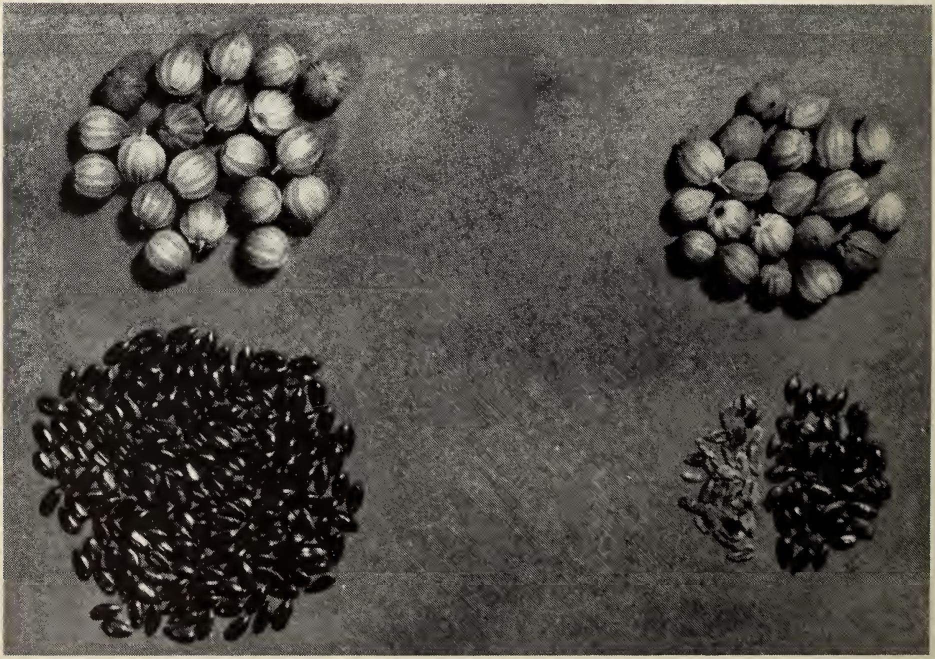
The disease usually appears first as small patches of dead flax. Patches one or two feet in diameter indicate that the disease has been present for two years. With each succeeding crop of flax on the same ground the wilt patches in a field will increase in size, and usually become irregular in shape because of movement of the pathogen by cultivating equipment or irrigation water.

Rhizoctonia seedling blight. This disease has frequently caused rather serious damage to some fields of flax in Imperial Valley. It is more severe when young seedlings grow in soil that remains wet on the surface. The causal agent of this disease attacks many other crop plants, including alfalfa, sugar beets, cotton, beans, and carrots.

Like Fusarium wilt this disease can persist in the soil on decaying organic matter. Symptoms of the disease are similar to those of Fusarium wilt. It may appear in large or small patches. Rhizoctonia has recently been reported as causing death of flax plants in Imperial Valley during the blossoming and seed-set period. At this stage it may be confused with Fusarium wilt.

Curly top was first observed on flax in California in March of 1944 when several fields in the San Joaquin Valley showed symptoms of the disease. With increases in the acreage of sugar beets in Imperial Valley, curly top has frequently been observed there. Damage was rarely as high as 5 per cent until 1955–56. In 1956 curly top was present in most fields, the number of infected plants ranging from 1 to 90 per cent. Estimates of the areas damaged by curly top varied from 4,000 to 12,000 acres.

Curly top is a virus disease originally described on sugar beet. The virus is spread from diseased to healthly plants during the process of feeding by the sugar beet leafhopper. In 1955–56 leafhopper counts ranged from 8 to 10 per



Effect of curly top on the bolls and seed of flax in Imperial Valley. The sample on the left is normal, the one on the right diseased. The seed samples in each case were obtained from 20 bolls.

100 sweeps in poor fields of flax to 1 per 100 sweeps in good fields. It is usually more severe in thin stands of flax, apparently because the leafhopper prefers to feed in such situations. The disease is not seed borne.

The disease may take various expressions. The most striking and distinct symptoms are distortion of the leaves of the growing point and puckering or blistering of the flowers. The branches may be spreading rather than upright and young plants may turn yellow and die. The most common symptom is a general yellowing of the plants, which is difficult to distinguish from nitrogen deficiency. The latter, however, is expressed more uniformly over the field, whereas curly top begins along the borders in thin and weak spots. The flowers of plants affected by curly top will often fail to open properly or adhere to the boll, but normal flowers of the second set often have this appearance. Infected plants usually produce a poor set of shrunken seed. When cut in cross section the root or crown will often show in the inner bark tissues an orange-yellow discoloration, which may be localized on one side or in one area.

Fields planted in December, January, and early February show less damage than those sown earlier or later. Damage is reduced in good stands of flax that grow vigorously. Avoid stresses from lack of water or lack of fertilizer. Herbicides at the recommended rates may cause serious damage in fields with curly top.

To reduce populations of the leafhopper

- control weeds which are hosts (lambsquarter, pigweed, mustard, Indian mustard, wild beets, five-hook bassia, and others), or
- maintain a beet-free period from early July to September.

Chemical control of the insect in the field has not been successful in controlling the disease.

Diseases not present in Imperial Valley

Anthracnose, a disease of humid areas, causes brown lesions on the plant.

Botrytis blight, also a disease of humid areas, usually affects only small portions of the plant—a single boll or branch.

Rust, first appeared in California in San Mateo County in 1952, has prohibited the production of Imperial Valley varieties in that area.

Pasmo, which rarely causes appreciable damage, produces lesions like anthracnose.

Browning may cause lesions like those of anthracnose, or it may cause stem-break, the breaking of the stem just above the soil surface.

Note: Anthracnose occurred in the San Joaquin Valley in 1940–41, the other four are flax diseases found in San Mateo County.

Insect control

Flax is attacked occasionally by insects that trouble other crops. The previous crop history or adjacent crops may have an important bearing on the incidence of these pests.

Cutworms may become a serious problem in young flax following alfalfa, or in weedy, trashy fields.

Bait: 80 per cent bran, 11 per cent oil, and 8 to 9 per cent of 25 per cent emulsifiable DDT, at 15 to 20 pounds per acre.

Dust: 10 per cent toxaphene at 30 pounds per acre by ground rig, and 30 to 35 pounds by airplane. 10 per cent

With new chemicals becoming available, and new formulations of old ones, the recommendations given in this circular may change. Your Farm Advisor will have the latest information on pest control.

DDT at 20 to 25 pounds per acre by ground rig, and 25 to 30 pounds by airplane.

Spray: toxaphene at 3 pounds per acre by ground rig, and 3 to 4 pounds by airplane. DDT at 1½ pounds per acre by ground rig, and 2 pounds per airplane.

Note: Ground application and spray preferred. Irrigation water frequently drives worms to surface when a DDT or toxaphene spray may be more effective.

Salt marsh caterpillars (wooly worms) migrating from cotton fields to adajcent flax fields can be particularly destructive to young stands of flax. The foraging of a single caterpillar can permanently destroy all the plants in a foot or two of a row in a matter of a few hours when plants are in the early seedling stage.

Bait: .516 pounds technical chlordane to 100 pounds of bran.

Paper or aluminum foil barrier is put around the field. Its effectiveness is increased by sprinkling a 2 per cent BHC dust outside the barrier at 5 pounds per 100 feet.

Beet army worms are destructive to growing tips of flax seedlings and to the inflorescences and bolls in later stages of growth.

Control: (also for the darkling ground beetle)

Dust: 5 per cent DDT at 15 to 20 pounds per acre by ground rig, and 25 to 30 pounds by airplane.

Spray: DDT at 1 pound per acre by ground rig, and 1¼ to 1½ pounds by airplane.

Note: Ground application preferred for darkling ground beetle.

Thrips have been observed in flax fields for many years. Thrip populations have shown a tendency to reach a peak coinciding with the full bloom period of flax. Considerable floral blast and failure of buds to reach maturity may be attributable to thrips. They feed by a rasping action generally on the tender parts of the plant and especially concentrate on the structures of the flowers and buds. Although it has been impossible to measure the extent of damage caused by thrips, it is believed to be of economic importance each year. A feasible control of thrips in flax fields has not been worked out.

Crickets may occasionally be numerous enough in seedling flax to require control.

Bait: 1 pound of 62 per cent technical chlordane to 1 gallon of deodorized kerosene, or its equivalent, and 100 pounds of bran, applied broadcast at 10 to 20 pounds per acre. May be applied to borders and the field irrigated to drive the crickets to the bait.

Spray: Actual aldrin or dieldrin at 2 ounces per acre, chlordane at 1 pound per acre, or heptachlor at 6 ounces per acre.

Harvesting and marketing

Flax is usually harvested by direct combining. This may require that the flax stand for a rather long period if summer weeds are present. Where weeds are not a problem, combining should be done after 90 per cent of the bolls have turned brown. Most flax is combined directly.

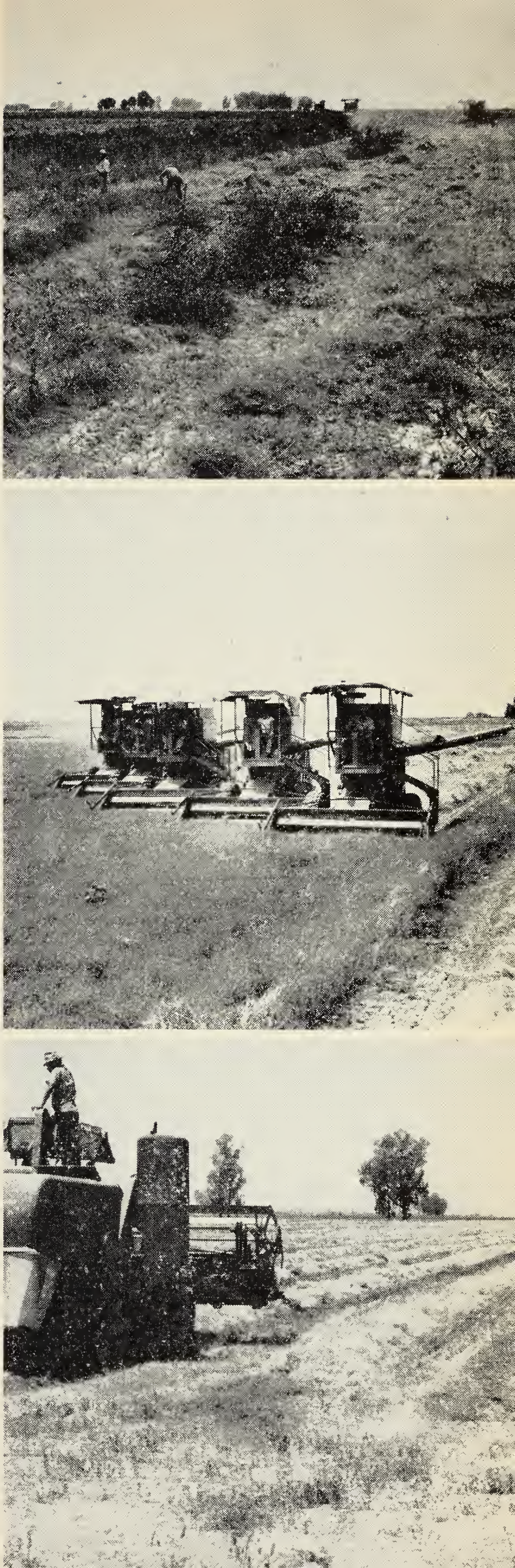
Some flax is windrowed, and threshed with a combine equipped with a pick-up attachment. Windrowing is the accepted method if a very heavy stand of summer weeds develop in the maturing flax. It should be done before the plants become dry and brittle. Windrowing usually results in greater seed losses than direct combining.

Most machines have angle-bar or rasp-bar cylinders which revolve at a peripheral speed of 5,000 to 6,000 feet per minute. Concave-cylinder clearances should vary from $\frac{1}{16}$ to $\frac{1}{4}$ inch; the wider spacing is preferred if it removes the seed from the flax bolls. Flax rolls are mounted ahead of the cylinder, one of these being steel and the other steel with a hard rubber surface. The rolls rotate at a peripheral speed of 300 to 400 feet per minute, one roll being set to rotate about 10 per cent faster than the other, to give a rubbing action on the flax bolls. The rolls have led to much more efficient threshing of flax; more seed is recovered, and seed injury is lessened. Peg-tooth cylinders may break the flax straw into small pieces which are difficult to remove from the seed.

Screen size and wind velocities are reduced from those for small grain. Combine adjustments may be necessary from time to time depending on temperatures, relative humidities and the condition of the flax. The skill of the operator is an important factor in efficient harvesting of flax.

Static electricity sometimes is a problem in harvesting flax. This condition may develop when temperatures exceed 100° F. and humidities are very low. Seeds tend to cling to one another and to the combine, screens become clogged, and serious seed loss may occur. This situation cannot be controlled; the only alternative is to delay harvest until the humidity increases slightly or until temperatures are low enough to prevent its occurrence.

Flax as it comes from the combine contains some (and occasionally large amounts of) dockage—weed seeds, other grain, short pieces of straw, and chaff. The dockage that most affects the grade



Top: Harvesting weedy flax in Imperial Valley by direct combining. Note that the large wild sunflowers are removed from the standing flax ahead of the combine. Center: Harvesting a clean field of flax by direct combining. Bottom: threshing flax from the windrow. Flax is windrowed prior to threshing when green weeds are present in the ripe flax.

are green weed seeds. If abundant they may raise the moisture content sufficiently to damage some of the flax. The grower receives no compensation for the dockage, but must pay the cost of shipping it to the processor.

Most flax in Imperial Valley is harvested with a moisture content below 6 per cent which is low enough for safe storage. The flaxseed may heat under Imperial Valley temperatures if the moisture content is above 8 per cent.

Markets for seed

Practically the entire flaxseed production of the Imperial Valley is handled in bulk and shipped by train to the Los Angeles area where it is marketed and processed. Much of the flax is marketed through a local grower-owned and operated organization. A small amount of the Imperial Valley flax is shipped to the San Francisco Bay area. Some is exported, the amount depending upon the world price.

Because of the high cost of freight it has not been feasible to supplement the California production with flaxseed grown in the Northern Great Plains. No flax has been brought into California from other countries because of import duties.

Products from the flax plant

Linseed oil

The oil from flaxseed, linseed oil, is used for a variety of products. Most of it goes into the paint and varnish industry. The oil after appropriate treatments or additives dries quickly into a tough film. It is also used in products such as linoleum, oil cloth, molds for castings, and printer's ink. The oil is not used for food, partly because the oil tends to develop undesirable flavors rather quickly after processing.

Flaxseed may contain from 32 to 44 per cent oil. In Imperial Valley the oil content is high, ranging from about 39 per cent to over 43 per cent. (See table, below.) Varieties may differ slightly in the amount of oil they contain, Imperial having less than Punjab 47 and Punjab 53 (table on page 6). New River has a higher oil content than any of the varieties grown commercially in California. Where flax is not irrigated sufficiently and suffers from lack of mois-

Oil Analysis of Shipments of Flax from Imperial Valley, Averages 1949–55*

Time of year	Oil content	Iodine value	Year	Oil content	Iodine value
	per cent†			per cent†	
June 14	41.9	185	1949	40.8	179
June 21	41.8	185	1950	40.4	182
June 28	41.3	184	1951	43.2	184
July 5	41.6	182	1952	42.3	185
July 12	41.5	183	1953	41.2	187
July 19	41.1	182	1954	40.6	181
July 26	41.1	182	1955	40.9	187
August 2	41.1	183			

* Data supplied by the Southwest Flaxseed Association, Imperial, California.
† On basis of actual moisture content.

ture as the seed develops, the seed is shrunken and low in oil. The high oil content of Imperial Valley flax is in part a reflection of its low moisture content which ranges from 5 to 6 per cent, in contrast to 8 to 10 per cent from the Northern Great Plains.

Oil content of commercial shipments appears to vary slightly from year to year (see table, page 22). On the basis of averages for a seven-year period, there is very little reduction in oil content of flax shipments from the Imperial Valley during the period from June 1 to August 1.

Iodine value or iodine number is an index of the value of linsed oil for use in paints and varnishes. The range of iodine value lies between 140 and 205 in extreme cases, but usually between 170 and 190. As with oil content, iodine value varies with different varieties and with different environments. In Imperial Valley it has rarely been lower than the normal commercial requirement of 177.

Most of the linseed oil produced in California is consumed in the state; only very small amounts are shipped to neighboring states. Under certain marketing arrangements the U. S. Department of Agriculture has moved some linseed oil from California onto the export market to reduce national surpluses. Small amounts of linseed oil come into California from the Northern Great Plains.

Linseed meal

The crude protein content of the meal or cake varies from 30 to 35 per cent, and usually averages around 34 per cent. The amount of oil in the meal depends on the method of processing, being 5 to 7 per cent if processed with a press or expeller, and 1 to 3 per cent if processed with solvents. The meal is popular with livestock feeders not only because of the high protein content, but also because of its good palatability and slight laxative effect.

Feed value of flax straw

Flax straw is rarely fed to livestock. If mature and of good quality, it is about equal to oat or barley straw in feed value. It can be used safely as the only roughage for cattle. The fibers are digested like other fibrous materials and do not accumulate in the stomach to form indigestible balls.

Be careful about feeding flax straw that has considerable green material in it because immature flax may contain

Feed Value of Flax Straw and Linseed Meal with Comparisons*

	Total dry matter	Average total composition					Digestible protein	Total digestible nutrients
		Protein	Fat	Fiber	N-free extract	Mineral matter		
	per cent	per cent	per cent	per cent	per cent	per cent	per cent	per cent
Flax straw	92.8	7.2	3.2	42.5	32.9	7.0	5.8	38.1
Oat straw	89.8	4.1	2.2	36.3	40.9	6.3	0.7	44.8
Barley straw	90.0	3.7	1.6	37.7	41.0	6.0	0.7	42.2
Linseed meal (o.p.)†	91.0	35.1	4.5	9.0	36.7	5.7	30.5	75.3
Linseed meal (s.p)†	90.1	36.6	1.0	9.3	38.3	5.8	30.7	70.3
Cottonseed meal‡	92.8	43.3	5.1	11.0	27.4	6.0	35.9	72.6

* Morrison, F. B. Feeds and Feeding. Morrison Publishing Co., Ithaca, N.Y. 1956.
† o.p.—old process, using hydraulic press or expellers; s.p.—solvent process.
‡ 43 per cent protein grade.

poisonous amounts of prussic acid. The danger is greater if the immature flax is frozen. Volunteer flax appearing after harvest may be unsafe as pasture.

Seed flax straw—a source of fiber

Large amounts of straw of seed flax are processed each year in the United States to obtain the fiber. One processing plant is located in the Imperial Valley. The yield of straw from seedflax is around ½ to ¾ ton per acre. The fiber content is about 10 per cent of the straw weight.

The company processing the straw for fiber in Imperial Valley takes the straw from the best fields only—those which have a dense and uniform stand of flax, and are free from weeds. Grasses are the most troublesome weeds because it is difficult to separate the grass straw from the flax fibers during processing. After harvesting the flax for seed, the straw is raked into windrows. If the combine had been set very high, it may be necessary to mow the field prior to raking. Enough straw is baled and piled near the processing plant to keep it in operation for an entire year. The price for the delivered straw varies between $13.00 and $15.00 per ton.

Processing equipment consists of a combination of corrugated rollers that break and crush the woody stems, and shakers that separate the broken woody portions from the long tangled fibers. The fiber is baled and shipped to a paper mill in North Carolina. There the fiber is manufactured into high-grade types of paper such as cigarette paper, Bible paper, carbon paper, and air-mail bonds.

Fiber flax

Linen, one of the finest of fabrics, is made from flax developed for that purpose. Such flax has long fine stems that produce a high-quality fiber.

A fiber-flax industry is not feasible in Imperial Valley because the extraction of fiber requires more hand labor and time than is justified by the returns. The yield of fiber probably would not exceed 400 pounds per acre, with the price being not much above 40¢ per pound.

The flax plants must be pulled by hand or by machines especially designed for this purpose. The pulled plants are tied into sheaves, and allowed to dry. Then the sheaves are soaked in a tank of water until the non-fibrous portions of the stem have "retted"—rotted in part. The retted sheaves are dried and stored for processing. Processing is similar to that described for the extraction of fiber from seed flax, except that all the fibers must be kept parallel and must not be permitted to tangle.

Production costs

Costs of producing flax in Imperial Valley, as detailed below, are about $30.00 per acre higher than they are for barley. Minimum costs would be about $75.00 per acre. With the price of flax ranging between $3.00 and $4.00 per bushel, it is understandable why many farmers feel that they cannot afford to grow flax unless they obtain at least 30 to 40 bushels per acre.

Costs of Production*

Items	Costs	
	Per acre	Per bushel†
Land preparation—labor and field power:		
Disc, border, disc, float, fertilize, irrigate, mulch, etc.	$10.50	$0.30
Cultural labor and field power:		
Planting across borders	2.00	
Fertilizing	2.00	
Irrigating—7 times	4.20	
Weed control	3.25	
Border and ditch work	2.00	
Miscellaneous	2.00	
Total	15.45	0.44
Materials:		
Irrigation water—2.5 feet	5.00	
Seed—42 lbs. at 13¢	5.00	
Fertilizer—120 lb. N, and 80 lb. P_2O_5	26.00	
Total	36.00	1.03
Harvesting:		
Combining in bulk	9.00	
Hauling	2.00	
Shipping costs to Los Angeles	5.10	
Total	16.10	0.46
Cash overhead:		
General expenses (5 per cent)	3.90	
Taxes	2.00	
Repairs	1.00	
Insurance	0.40	
Total	7.30	0.21
Depreciation	2.50	0.07
Land rent	30.00	0.86
Total costs:	117.85	3.37
Less returns for straw	4.00	0.11
Total	113.85	3.26

* Data from the Agricultural Extension Service, Imperial County, 1956.
† Based on a yield of 35 bushels per acre.

Goals for research

Flax research in California is conducted by many departments within the University of California and the United States Department of Agriculture, including the Imperial Valley Field Station, the Southwestern Irrigation Field Station, the Agricultural Extension Service of Imperial County, and the University at Davis and Riverside. In most instances the research is cooperative among personnel of the various agencies, and often research information from other states, such as Minnesota and North Dakota, is utilized. Here is a list of current research projects that will benefit flax production in Imperial Valley:

Development of improved varieties: Resistance to Fusarium wilt greater than that of Punjab 53 and New River is being added to the varieties Punjab 47 and Imperial. A search is being made for resistance to curly top and Rhizoctonia wilt.

Inheritance studies: Studies are under way on the inheritance of such items as resistance to Fusarium wilt, resistance to rust, oil content and quality, and tolerance to 2,4-D. Such studies put plant breeding on a more precise or scientific basis.

Culture: Some research is being done on the fertilizer and irrigation requirements of flax, but more is necessary. Unfortunately results from such research are often applicable only in the field or area where the research is done.

Pest control by chemicals: Constant experimentation is necessary to keep abreast of developments in herbicides, insecticides and fungicides.

Improvement in linseed oil: Research in this field will permit linseed oil to compete more effectively with other vegetable oils of commerce. It is hoped that flax varieties may be found that will provide widely different types of linseed oil.

California ranks low in the United States as a flax-producing state, but seed yields per acre greatly exceed those of other states as shown in the table below:

Comparison of U. S. Flaxseed Producing States, 1945–1954*

	Acreage harvested	Yield	Production	Price per bu
	1,000s	bu/A†	1,000 bu	
North Dakota	1,869	7.9	14,780	$3.98
Minnesota	1,218	10.2	12,377	4.00
South Dakota	610	8.6	5,233	3.97
Texas	136	6.7	911	3.74
Montana	105	6.2	650	3.86
California	94	23.0	2,164	4.42
Other states	158	11.7	1,844	....
Total	4,190	9.0	37,959	3.99

* USDA Agricultural Statistics.
† The bushel weight for flax is 56 pounds

Scientific names

Weeds

Wild oats	*Avena fatua*
Canary grass	*Phalaris minor*
Wild mustard	*Brassica kaber*
Field mustard	*Brassica campestris*
Sour clover	*Melilotus indica*
Hubam clover	*Melilotus alba annua*
Redweed	*Polygonum argyrocoleon*
Indian mustard	*Sysimbrium irio*
5-hook bassia	*Bassia nysspoifolia*
Nettle-leafed goosefoot	*Chenopodium murale*
Lambsquarter	*Chenopodium album*
Pigweed	*Amaranthus powellii*
Wild sunflower	*Helianthus annuus*
Wild beets	*Beta maritima*
Water grass	*Echinocloa crusgalli*

Insects

Cutworms	Family Noctuidae
Beet armyworm	*Laphygme exigua* (Hbn.)
Darkling ground beetles	Family Tenebrionidae
Crickets	Family Gryllidae
Beet leafhopper	*Circulifer tenellus* (Baker)
Salt marsh caterpillar	*Estigmene acraea* (Drury)
Thrips	*Frankliniella* sp.

Diseases

Wilt	*Fusarium oxysporum* f. *lini*
Seedling blight	*Rhizoctonia solani*
Anthracnose	*Colletotrichum lini*
Botrytis blight	*Botrytis cinerea*
Rust	*Melampsora lini*
Pasmo	*Sphaerella linorum*
Browning	*Polyspora lini*

In order that the information in our publications may be more intelligible, it is sometimes necessary to use trade names of products and equipment rather than complicated descriptive or chemical identifications. In so doing, it is unavoidable in some cases that similar products which are on the market under other trade names may not be cited. No endorsement of named products is intended nor is criticism implied of similar products which are not mentioned.

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FOR FURTHER INFORMATION

on agronomy opportunities write to Maurice L. Peterson, chairman, agronomy department.

on entrance requirements write to Howard B. Shontz, office of the registrar.

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